PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/812,406
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Applicant:	TAKASE et al.
Group Art Unit:	1742
Examiner:	MORILLO, Janelle Combs
Title:	WEAR-RESISTANT ALUMINUM ALLOY EXCELLENT IN CAULKING PROPERTY AND EXTRUDED PRODUCT...
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Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

SUPPLEMENTAL AFFIDAVIT OF NOBUYUKI HIGASHI TRAVERSING REJECTION UNDER 37 CFR 1.132

Sir:

I, Nobuyuki HIGASHI, state as follows:

1. I graduated from Toyama University in 1985 with a bachelor's degree in Material Engineering.

2. In 1990, I started working for AISIN KEIKINZOKU CO., LTD. as an engineer in the Technical Development Department. My current position is

Manager of Quality Group, Quality Assurance Department.

3. I am an inventor of the subject matter claimed in the above-identified patent application.

4. The claimed invention is directed to a wear-resistant aluminum alloy or extruded product that is excellent in caulking properties.

5. The composition of the alloy and extruded product of the claimed invention includes 0.1 to 0.39 wt% of Mg, 3.0 to 6.0 wt% of Si, 0.01 to 0.20 wt% of Cu, 0.01 to 0.5 wt% of Fe, 0.01 to 0.15 wt% of Mn, 0.01 to 0.5 wt% of Cr, less than 0.02 wt% of Zn, and the remainder being Al and unavoidable impurities.

6. The wear-resistant aluminum alloy and extruded product having the composition of paragraph 5 are suitable for use in automotive break parts for which wear resistance to sliding parts and viscosity during plastic deformation such as caulking are required.

7. To evaluate caulking properties of the alloy or extruded product, the calculation of a critical upsetting ratio may be used. The critical upsetting ratio occurs when microcracks develop during compression of the alloy or extruded product.

8. The critical upsetting ratio of the alloy and extruded product of the claimed invention is greater than or equal to 43%.

9. The composition of the claimed invention also satisfies the numerical expression $0.79 \cdot (\text{wt\% of Mn}) + 0.26 \cdot (\text{wt\% of Mg}) \leq 0.22$, which significantly affects the critical upsetting ratio as shown in Figure 4 of the present

application.

10. The coefficients 0.79 (Mn) and 0.26 (Mg) were calculated using a multiple regression analysis of the relationship between the critical upsetting ratio as an evaluation item of caulking properties and the alloy components.

11. The critical upsetting ratio is significantly affected by the Mg content and the Mn content in the claimed ranges of 0.1 to 0.39 wt% and 0.01 to 0.15 wt%, respectively.

12. Reference Figure 1 (attached at Exhibit A) shows the relationship between the expression 0.79·(wt% of Mn)+0.26·(wt% of Mg) using the coefficients calculated using the multiple regression analysis and the critical upsetting ratio (%).

13. As can be seen in Reference Figure 1, the horizontal axis indicates the value of 0.79·(wt% of Mn)+0.26·(wt% of Mn), and the vertical axis indicates the critical upsetting ratio (%).

14. The plot numbers shown in Reference Figure 1 indicate Nos. 1 to 10 shown in Figure 1 of the present application, and supplemental data Nos. 11 to 18 as comparative examples.

15. The supplemental data Nos. 11 to 18 were selected from the ranges disclosed in the cited reference JP 09-176769 ('769).

16. The alloy I of JP '769 (No. 9 in Table 2-1) contains Mg in an amount of 0.40 wt%, which is greater to a small extent than the upper limit (0.39 wt%) for Mg of the claimed invention, and contains Mn in an amount within the range of

the claimed invention. Therefore, alloy I of JP '769 (No. 9 in Table 2-1) is the prior art closest to the present invention.

17. Reference Figure 2, attached as Exhibit B, shows the alloy compositions and the critical upsetting ratios of the supplemental data Nos. 11 to 18.

18. As is clear form Reference Figure 1, alloy Nos. 1 to 6, 8 and 9 according to the claimed invention and the supplemental data Nos. 11 to 18 (comparative examples selected from JP '769) clearly belong to different groups.

19. When the value indicated by the horizontal axis is x and the value indicated by the vertical axis is y, alloy Nos. 1 to 6, 8 and 9 according to the claimed invention belong to a first group approximated by $y = -100.46x + 65.55$ (R^2=0.84, linearly approximated statistically), and the supplemental data Nos. 11 to 18 belong to a second group approximated by $y = -13.40x + 43.68$ (R^2=0.50, almost linearly approximated statistically).

20. The minimum upsetting ratio of the alloys according to the claimed invention shown in Figure 1 is 43.1%. In this case, the value of 0.79xMn+0.26xMg is 0.22 (upper limit).

21. In contrast, the supplemental data Nos. 11 to 18 which were selected from JP'769 have a value of 0.79(wt% of Mn) +0.26(wt% of Mg) of more than 0.22, as shown in Reference Figure 1.

22. Supplemental data No. 16 was prepared to coincide with alloy I of JP '769 (No. 9 in Table 2-1), but differs from the alloy I of JP '769 as to the Si, Fe, and Ti content by 0.02 wt%. This is the difference between the amount of

component added when adding each component to pure aluminum and casting an aluminum alloy and the amount of component determined by analyzing the produced aluminum alloy.

23. Comparative Example No. 16 had a Si content of 4.04%, which is smaller than that of Alloy I (4.06%) of JP '769 by 0.02%.

24. Comparative Example No. 16 had an Fe content of 0.30%, which is larger than that of Alloy I (0.28%) of JP '769 by 0.02%.

25. Comparative Example No. 16 had a Ti content of 0.03%, which is smaller than that of Alloy I (0.05%) of JP '769 by 0.02%.

26. The effects of Si, Fe, and Ti are discussed below.

27. JP '769 and the specification of the present application disclose that Si improves wear resistance.

28. The effects of Si on wear resistance increase as the Si content increases from 3.0% to 6.0%. Specifically, the difference in Si content of 0.02% between Comparative Example No. 16 and Alloy I affects wear resistance to only a small extent.

29. As disclosed in the specification of the present application, caulking properties decrease when increasing wear resistance. Therefore, the critical upsetting ratio increases due to the fact that Comparative Example No. 16 had an Si content smaller than that of Alloy I of JP '769 by 0.02% even if caulking properties are affected to only a small extent. This means that Comparative Example No. 16 is closer to the claimed invention than Alloy I of JP '769.

30. JP '769 and the specification of the present application disclose that Fe affects a grain refinement effect. The difference in Fe content of 0.02% between 0.28% (Alloy I) and 0.30% (Comparative Example No. 16) does not affect an improvement in caulking properties (increase in critical upsetting ratio), which is the object of the claimed invention.

31. Ti also affects a grain refinement effect. If the Ti content is in the range of 0.01% to 0.2%, no significant difference occurs in practical application. In particular, the Ti content of Alloy I of JP '769 and Comparative Example No. 16 is small as 0.05% and 0.03%, respectively, and the difference of 0.02% does not affect caulking properties.

32. The components that affect an improvement in caulking properties, which is the object of the claimed invention, are Mn and Mg as shown in Reference Figure 1, and the effects of Si, Fe, and Ti are small. Therefore, Comparative Example No. 16 is an alloy substantially the same as Alloy I of JP '769. When the effects of Si, Fe, and Ti are taken into consideration, Comparative Example No. 16 is closer to the claimed invention than Alloy I of JP '769.

33. The supplemental data Nos. 16-18 contain a Mg content that is just slightly outside of the claimed range of 0.39 wt%.

34. Supplemental data Nos. 16 to 18 was prepared as data representing JP '769. The Mg and Mn ranges of the experimental data Nos. 17 and 18 were almost the same as those of the experimental data No. 16. On the

other hand, the Si content was increased in the order of No. 16. (Si: 4.04 wt%), No. 17 (Si: 4.52 wt%), and No. 18 (Si: 4.98 wt%).

35. The alloy composition of Comparative Example No. 16 analyzed after production was compared with the alloy composition of Alloy I disclosed in JP '769. Regarding Mn and Mg, which affect the critical upsetting ratio (object of the claimed invention) to a large extent (see Reference Figure 1), Comparative Example No. 16 and Alloy I had an Mn content of 0.19% and a Mg of 0.40%. However, Comparative Example No. 16 and Alloy I differ to some extent as to other components.

36. As described in the specification of the present application, it was found that Mg and Mn affect critical upsetting ratio to the largest extent as a result of statistical analysis on the effects of each component.. The key index of the claimed invention is critical upsetting ratio.

37. Comparative Example No. 16, therefore, was produced to have the same composition as Alloy I of JP '769, closest to the claimed Invention, and was compared with the alloys of the claimed Invention.

38. Comparative Example No. 16 and Alloy I have an Mg content of 0.40% and an Mn content of 0.19%, but differ to some extent as to the content of other components. However, Comparative Example No. 16 is closer to the claimed invention that Alloy I.

39. The extruded products of the claimed invention having the compositions shown in Table 1 were cast from eight inch billets. The billets were subjected to a homogenization treatment at 460 to 590 C for six hours or more,

and hot-extruded at 450 to 510 C. The hot extruded product was quenched and subjected to an artificial aging treatment by performing a heat treatment at 160 to 195 for 2 to 8 hours.

40. Similarly, Alloys Nos. 11-18 including Comparative Example No. 16 were produced under the same conditions as Alloys Nos. 4 and 6 shown in Table 2 of the present application. That is, Alloy Nos. 11-18 were cast from eight inch billets and subjected to a homogenization treatment at 510 C for six hours, and hot-extruded at 470 C. The extruded product was quenched and subjected to an artificial aging treatment at 170 C for four hours.

41. The casting method disclosed in JP '769 may be found in paragraph [0009] of JP '769, which states that "Alloys having compositions shown in Tables 2-1 and 2-2 were eight-inch billets. The billet was subjected to a homogenization treatment at 510 C for six hours, and then hot-extruded at 470 C. After quenching, the extruded product was subjected to an artificial aging treatment at 195 C for three hours."

42. The casting method of JP '769, therefore, is the same as that of Comparative Example No. 16 with regard to billet diameter, homogenization treatment conditions, and billet extrusion temperature. The casting method of JP '769 differs only to a small extent from that of Comparative Example No. 16 as to the artificial aging conditions.

43. The artificial aging conditions (i.e., at 170C for 4 hours) for Alloys Nos. 11 to 18, which include Comparative Example No. 16, however, were

selected so that the critical upsetting ratio increases within the range (i.e., at 160 to 195 C for 2 to 8 hours) of the claimed invention.

44. More particularly, although there is difference between the artificial aging conditions (i.e., at 170 C for 4 hours) for Alloys Nos. 11 to 18 and the artificial aging conditions (i.e., at 195 C for 3 hours) for Alloy I of JP '769, it is significant to note that JP '769 does not aim at improving caulking properties.

45. In this regard, JP '769 describes that artificial aging temperature is preferably 180 to 200 C from the viewpoint of strength (see paragraph [0008] of JP '769). When taking caulking properties into account as in the claimed invention, however, it is appropriate as a comparative example to treat Alloy I of JP '769 at 170 C for 4 hours rather than at 195 C for 3 hours. This is clear from the comparison between the critical upsetting ratios of Alloys Nos. 19 to 21 and the critical upsetting ratios of Alloys Nos. 16 to 18.

46. As shown at Exhibit C, Alloy Nos. 19 to 21 have the same composition as Alloys Nos. 16 to 18, but differ in artificial aging conditions (i.e., at 195 C for 3 hours) from Alloys Nos. 16 to 18 (i.e., at 170C for 4 hours). The data relating to Alloys Nos. 19-21 was obtained at the same time as Alloys Nos. 11 to 18. The data relating to Alloys Nos. 19 to 21 is inferior to Alloys Nos. 16 to 18 as to critical upsetting ratio.

47. Specifically, the critical upsetting ratios of Alloys Nos. 16 to 18 are higher than the critical upsetting ratios of Alloys Nos. 19 to 21, and the critical upsetting ratios of the alloys according to the claimed invention are higher than the critical upsetting ratios of Alloys Nos. 16 to 18.

48. As stated above, Comparative Example 16 has a composition closest to the claimed invention among the alloys of JP '769, and was produced using the processing parameters that maximize critical upsetting ratio.

49. The claimed invention achieves, however, a critical upsetting ratio higher than that of Comparative Example 16.

50. Accordingly, the claimed invention achieves unexpected results in comparison to the prior art alloys.

51. Such unexpected results are achieved by the claimed alloy composition. In particular, the Mg content (i.e., 0.1 to 0.39%) of the claimed invention ensures such unexpected results in comparison to JP '769 (Mg content: 0.4 to 0.1%).

52. Surprisingly, critical upsetting ratios of the experimental data Nos. 16 to 18 are smaller to a large extent than the value (43% or more) defined in the claimed invention, as shown in Reference Figure 1.

53. Quite unexpectedly, even though the comparative alloy Nos. 11 to 18 that were taken from the alloys disclosed JP '769, and in particular alloy Nos. 16-18 have a Mg content that is very close to the claimed range of 0.39 wt% and were subjected to artificial aging treatments to maximize the critical upsetting

ratio, only the critical upsetting ratio of the claimed combination is greater than or equal to 43%.

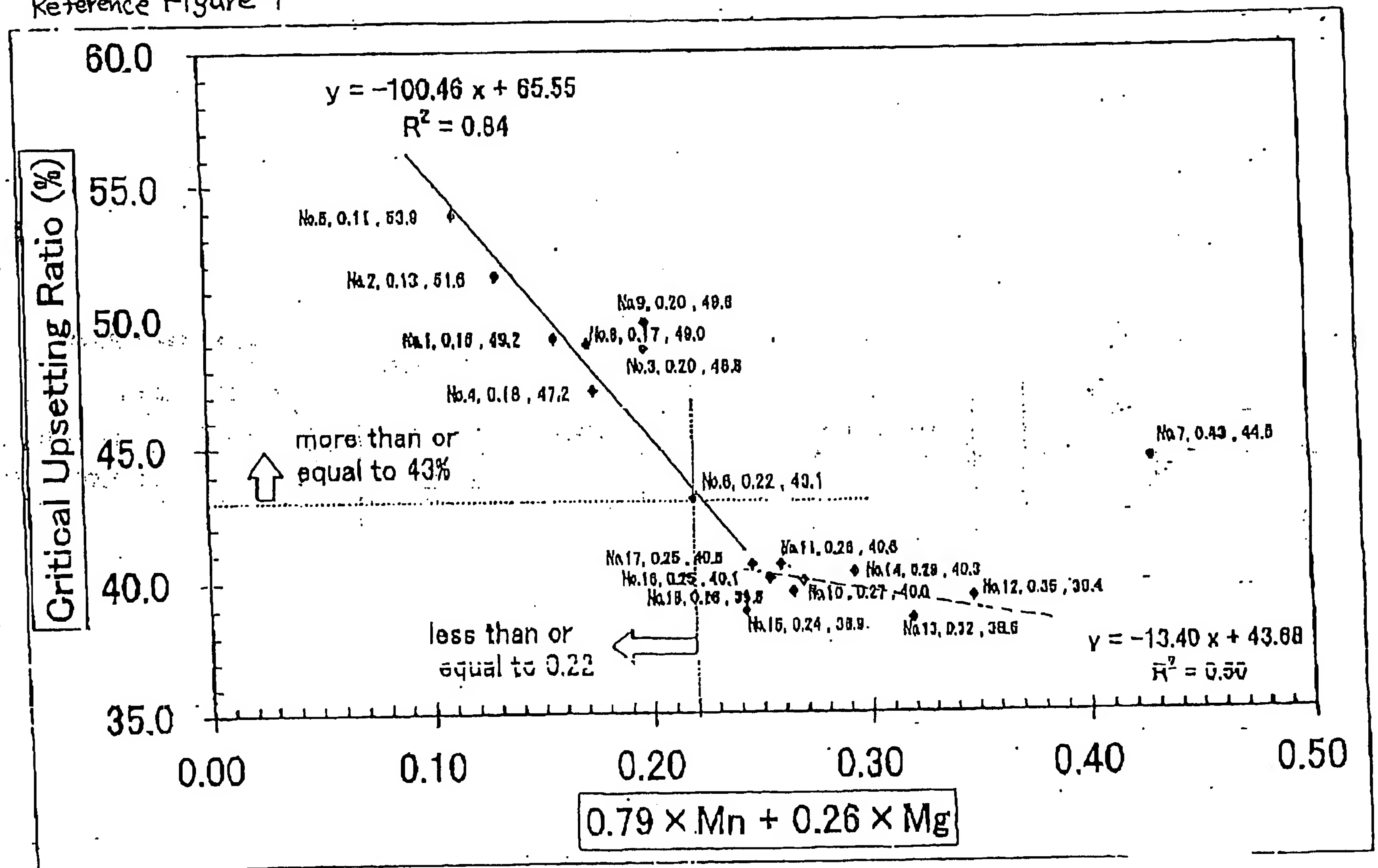
54. I hereby submit that all the above statements made from my own knowledge are true, and that all the above statements made on information and belief are believed to be true.

55. I also hereby acknowledge that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. § 1001) and may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

Date: 1. July 2008 By: Nobuyuki Higashi
Nobuyuki HIGASHI

Reference Figure 1



Reference Figure 2

	NO.	COMPONENTS (%)								CRETICAL UPSETTING RATIO (%)
		Si	Fe	Cu	Ti	Mn	Mg	Cr	Zn	
COMPARATIVE EXAMPLE	11	3.85	0.28	0.15	0.03	0.16	0.51	0.15	0.01	40.6
	12	4.96	0.29	0.16	0.04	0.24	0.61	0.14	0.00	39.4
	13	3.97	1.06	0.14	0.03	0.20	0.62	0.10	0.01	38.6
	14	4.17	0.29	0.96	0.03	0.18	0.58	0.10	0.01	40.3
	15	4.59	0.30	0.15	0.03	0.11	0.60	0.10	0.01	38.9
	16	4.04	0.30	0.15	0.03	0.19	0.40	0.15	0.01	40.1
	17	4.52	0.29	0.16	0.04	0.18	0.40	0.15	0.01	40.6
	18	4.98	0.26	0.15	0.03	0.20	0.41	0.10	0.01	39.6

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COMPARATIVE EXAMPLE

	NO.	COMPONENTS (%)								CRITICAL UPSETTING RATIO (%)
		Si	Fe	Cu	Ti	Mn	Mg	Cr	Zn	
	19	4.04	0.30	0.15	0.03	0.19	0.40	0.15	0.01	38.3
	20	4.52	0.29	0.16	0.04	0.18	0.40	0.15	0.01	38.7
	21	4.98	0.28	0.15	0.03	0.20	0.41	0.10	0.01	37.9

Nos. 19-21 were subjected to artificial aging at 195°C for 3 hours.